The Engineering News.

JUNE, 1875.

Petroleum and other Mineral Oils applied to the manufacture of Gas.

A PAPER READ BY O. C. D. ROSS, M. INST. C. E., BEFORE THE INSTITUTION OF CIVIL ENGINEERS OF LONDON.

During the last ten years the rapidly-increasing rate of consumption of coal in Great Britain, leading, it is feared, to the exhaustion of the coal fields, and contemporaneously to the decline of England's supremacy in the course of one or two centuries, has periodically elicited cries of alarm from the eminent men who have most carefully examined the subject. This alarm is due, in a great measure, to the belief that no substitute for coal as an economical heat and light-producing material is to be met with.

It is estimated that the quantity of coal consumed in the United Kingdom in the manufacture of gas in the year 1873, was no less than 6,560,000 tons, or nearly twice as much as was used during the same period on all the railways in the country; and an analysis of the quantity of carbon (which is the light-giving ingredient) contained in the gas produced from that enormous amount of coal, reveals the startling fact, that the same quantity of carbon might be practically obtained, and the same quantity of gas be manufactured, from very little more than 400,000 tons of petroleum or other mineral oils, which is about one-third of the quantity now exported from America to Europe.

The calculation on which this statement is based is an extremely simple one. The analysis of the gas supplied by the Chartered Gas Company, (see following table) shows that \$3,000 cubic feet of coal gas contain 33.381 lbs. of carbon; and 9,000 cubic feet of gas being about the average quantity produced from one ton of bituminous coal, it follows that the carbon contained in the gas made from 6,560,000 tons of coal has the weight of only 292,857 tons, of which Marsh gas, usually considered as non-illuminating, forms nine-tenths.

Composition of 100 lbs., or 3,000 cubic feet, of Coal Gas, as applied by the Chartered Gas Company of London.

		Proportionate Amount of	
		Carbon	Hydrogen
Illuminating hydro-carbons (bi-carburetted hydrogen, C H)	lbs. 3·530	lbs. 3·096	lbs. 0·434
Marsh gas (caburetted hydrogen, C H)	35·260	26·445	8·815
Carbonic oxide	8·950	3·840	5·110
Hydrogen	51·800	..	51.800
Nitrogen	0·380	..	..
Oxygen	0·080	..	..
Total lbs.	100·000	33·381	66·159

Now, the petroleum which the Author uses for making illuminating gas is composed, according to the analysis of Messrs. Pelouze and Cahours, of 71·74 per cent. of carbon, and 28·26 per cent. hydrogen, so that 1 ton of this material, the whole of which is vaporised and utilised in the oil gas, presently to be described, contains 1,607 lbs. of carbon. Thus 408,214 tons of this petroleum would be sufficient to supply the whole of the above-mentioned 292,857 tons of carbon; that is to say, the entire quantity of light-giving material contained in the gas extracted, by a process which is not inappropriately described as 'destructive distillation,' from 6,500,000 tons of coal. Here, then, there is evidently a large field for economy in the consumption of coal.

Gas made from petroleum spirit, or naphtha, as it is called in the United States, has recently been the subject of the American Association. In a paper read by the engineer to the "Citizen's Gas Light Company" of Brooklyn, it is stated that there are now fourteen cities and towns in America where naphtha gas is used unmixed, and that in many other places it is used in combination with coal gas.

In answer to objections, its American advocates assert:—1st, that, far from being more condensable than coal gas, there is a marked decrease in drip liquor since they used it, and that there is no foundation for the belief that there is any loss in its illuminating power at a distance from the works; 2ndly, that it is at least one-third cheaper than coal gas; 3rdly, that large open stores of coal are much more dangerous than naphtha or petroleum properly stored. It was added, by one of the directors of the Citizen's Gas Light Company, that the manufacture of naphtha gas involves hardly any labour, a foreman and four or five men being sufficient to attend to the manufacture of from 300,000 to 480,000 cubic feet per diem, which is the daily make of that company. This renders the Company, he remarked, independent of strikes.

The process by which the gas advocated by the Author is manufactured from petroleum spirit differs from that adopted in America, where superheated steam is the medium used for holding the luminiferous vapour. It simply consists in carburetting atmospheric air by passing it through a vessel, called the "carburettor," containing the oil, from which vessel the air emerges saturated with hydro-carbon vapour to a greater or less extent, at the option of the manipulator, and forms an inflammable mixture, in which the quantity of carbon ought to be about equal in amount to that contained in an equal volume of coal gas. The air is but little more than the medium for holding the hydro-carbon vapour, and for conveying it to the burners, with this further advantage, however, that the oxygen that composes one-fifth of the volume of atmospheric air, serves to insure the complete combustion of the vapour.

The apparatus by means of which the process is effected is of the simplest description, and consists of a fan, which, revolving slowly, draws or drives a current of air through the carburettor. This fan can be set in motion either by the use of a spring or of a falling weight, or by water or steam power; in fact, by whatever means may be best suited to the locality. For moderate-sized apparatus a common gas meter can be used for the purpose, motion being given to it mechanically instead of by the pressure of the gas.

In order to be able to decide upon the value of this gas, several points require to be considered:—1st, its quality, as regards illuminating power and permanency; 2d, its cost; 3d, its superiority in special situations where coal gasworks would be too costly or too troublesome, and more particularly where coal is exceptionally expensive, as happens in many foreign countries; and 4th, the question as to whether its use would involve danger.

1. As to its illuminating power. The American discussion elicited the fact that it can be made of 80-candle power; *i. e.*, to give the light of 80 candles when burnt at the rate of one cubic foot per hour, and so obtain the light of 16 candles. This involves using the oil vapour in a much denser condition than the author would recommend, but it can be made without any inconvenience of from 30 to 35 candle-power.

The question as to its permanency, which is the most important, requires to be more fully examined. The belief that oil gas will condense in the pipes in consequence of the lower temperature it there meets with is very general, and this is not surprising. First, because attempts formerly made to use oil, and especially the attempts to carburet air with the vapour of benzine or of petroleum, are known to have failed; and, secondly, because gas made from all ordinary oils or resins must be condensed. It is only those oils or spirits of low specific gravity, distilled from petroleum, coal tar, and shale oils, which will supply a gas that will not be condensed; and, until within the last few years, these were unknown or regarded as prejudicial in the manufacture of lamp oil, and therefore were allowed by the distillers to go to waste. The reason for this difference in the oils, as to the condensation of their vapour when used for making gas, is that ordinary oils have a high boiling point, and consequently require to be considerably heated to give off a vapour of sufficient density to burn as gas. But the boiling points of oils vary enormously, and the light oils or naptha, have so low a boiling point, that they will, even at a very low temperature, give off the requisite amount of vapour to carburet air and produce a brilliant flame.

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CONVEYANCING.—A great deal of useless and vexations litigation might be avoided if parties, before making out a conveyance of land, would submit the description of the property to be conveyed to a competent Surveyor. There are matters of measurement in connection with the division of the ordinary section that it seems impossible for any but practical surveyors to fully understand, and which are neglected almost universally by conveyancers, and thus become sources of future litigation and needless expense. Lawyers and real estate dealers are not the proper persons to describe the legal boundaries of land any
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263. In ascertaining the boundaries of a grant, when a point is described, as being a given distance from a certain other point, a direct line is implied, unless there be something to rebut the implication; and the circumstance that both points are on the same river, has no tendency to destroy the implication. Slade v. Etheridge, 13 Ired. (N. C.), 353.

264. What are the boundaries of a tract of land is a mere question of construction, and for the court, but where a line is, and what are the facts, must be found by a jury. Burnett v. Thompson, 13 Iredell (N. C.), 379.

265. In the absence of satisfactory proof of marked lines and corners, the plat and certificate of survey accompanying the grant, will be evidence of the locality of the land granted. Tate v. Gray, 1 Swan (Tenn.), 73.

266. When the boundaries of land are indefinite and uncertain, if run out and marked by the owner, it will be presumed, as against him, that it was correctly done; this presumption, however, may be removed by proof of a mistake, and that the lines as marked, vary materially from the true lines. Cunningham v. Roberson, 1 Swan (Tenn.), 138.

267. The original descriptions of the subdivisions of the public lands, made by the Surveyor-General from the field notes or books of the Deputy Surveyor, and the plats showing such subdivisions, are evidence as to their boundaries; and duly authenticated copies of such descriptions and plats are also evidence. Madison City v. Hildreth, 2 Carter (Ind.), 274.

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The number of a lot and of the block it is in, together with the name or title of the subdivision, are all that should go in a conveyance; to add a description of the lot by "metes and bounds" is not only unecessary, but often actually mischievous.

A *chain* is 100 links or 66 feet in length, and in multiplying or dividing chains and links the same system of notation is used as in that of dollars and cents. There are 100,000 square links in one acre, so that to know how many acres are in any piece of land, having found the area in square links, "point off" the five right hand figures and the remaining left hand figures denote the acres, and the part cut off denotes the fraction of an acre. If the area has been reduced to square feet divide the amount by 43560 which represents the number of square feet in one acre.

SOLAR PARALLAX. — The methods which serve in astronomy to determine the parallax of the sun can be classed into three groups:—

1. *Physical methods*, founded on observation of an optical phenomenon; they comprise the observation of the eclipses of Jupiter's satellites, or the aberration of the fixed stars, combined with the value for the velocity of light deduced without the intervention of other astronomical phenomena; the results of these methods are $\epsilon = 8''{\cdot}88$, $8''{\cdot}88$. $8''{\cdot}80$. Mean $8''{\cdot}85$.

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Gas made from petroleum spirit, or naphtha, as it is called in the United States, has recently been the subject of the American Association. In a paper read by the engineer to the "Citizen's Gas Light Company" of Brooklyn, it is stated that there are now fourteen cities and towns in America where naphtha gas is used unmixed, and that in many other places it is used in combination with coal gas.

In answer to objections, its American advocates assert:—1st, that, far from being more condensable than coal gas, there is a marked decrease in drip liquor since they used it, and that there is no foundation for the belief that there is any loss in its illuminating power at a distance from the works; 2ndly, that it is at least one-third cheaper than coal gas; 3rdly, that large open stores of coal are much more dangerous than naphtha or petroleum properly stored. It was added, by one of the directors of the Citizen's Gas Light Company, that the manufacture of naphtha gas involves hardly any labour, a foreman and four or five men being sufficient to attend to the manufacture of from 300,000 to 480,000 cubic feet per diem, which is the daily make of that company. This renders the Company, he remarked, independent of strikes.

The process by which the gas advocated by the Author is manufactured from petroleum spirit differs from that adopted in America, where superheated steam is the medium used for holding the luminiferous vapour. It simply consists in carburetting atmospheric air by passing it through a vessel, called the "carburettor," containing the oil, from which vessel the air emerges saturated with hydro-carbon vapour to a greater or less extent, at the option of the manipulator, and forms an inflammable mixture, in which the quantity of carbon ought to be about equal in amount to that contained in an equal volume of coal gas. The air is but little more than the medium for holding the hydro-carbon vapour, and for conveying ing it to the burners, with this further advantage, however, that the oxygen that composes one-fifth of the volume of atmospheric air, serves to insure the complete combustion of the vapour.

The apparatus by means of which the process is effected is of the simplest description, and consists of a fan, which, revolving slowly, draws or drives a current of air through the carburettor. This fan can be set in motion either by the use of a spring or of a falling weight, or by water or steam power; in fact, by whatever means may be best suited to the locality. For moderate-sized apparatus a common gas meter can be used for the purpose, motion being given to it mechanically instead of by the pressure of the gas.

In order to be able to decide upon the value of this gas, several points require to be considered:—1st, its quality, as regards illuminating power and permanency; 2d, its cost; 3d, its superiority in special situations where coal gasworks would be too costly or too troublesome, and more particularly where coal is exceptionally expensive, as happens in many foreign countries; and 4th, the question as to whether its use would involve danger.

1. As to its illuminating power. The American discussion elicited the fact that it can be made of 80-candle power; *i. e.*, to give the light of 80 candles when burnt at the rate of one cubic foot per hour, and so obtain the light of 16 candles. This involves using the oil vapour in a much denser condition than the author would recommend, but it can be made without any inconvenience of from 30 to 35 candle-power.

The question as to its permanency, which is the most important, requires to be more fully examined. The belief that oil gas will condense in the pipes in consequence of the lower temperature it there meets with is very general, and this is not surprising. First, because attempts formerly made to use oil, and especially the attempts to carburet air with the vapour of benzine or of petroleum, are known to have failed; and, secondly, because gas made from all ordinary oils or resins must be condensed. It is only those oils or spirits of low specific gravity, distilled from petroleum, coal tar, and shale oils, which will supply a gas that will not be condensed; and, until within the last few years, these were unknown or regarded as prejudicial in the manufacture of lamp oil, and therefore were allowed by the distillers to go to waste. The reason for this difference in the oils, as to the condensation of their vapour when used for making gas, is that ordinary oils have a high boiling point, and consequently require to be considerably heated to give off a vapour of sufficient density to burn as gas. But the boiling points of oils vary enormously, and the light oils or naptha, have so low a boiling point, that they will, even at a very low temperature, give off the requisite amount of vapour to carburet air and produce a brilliant flame.

Now, all vapours have a certain tension or elastic power, which varies with the temperature; the higher the temperature the greater is their tension. If when confined in, or permeating, a vacuum or a given volume of air (for the effect is the same in both cases), their maximum tension is not attained, they will remain perfectly elastic, and will expand or diminish in volume with an increase or decrease of temperature, precisely as any permanent gas will do. When, however, their maximum tension is exceeded; if, for example, a vacuum or a given volume of air has been filled or saturated with vapour obtained from oil heated to 100°, and the temperature is lowered to 50°, then, its tension or elastic power being greatly reduced, a portion of the vapour will be forced back to the liquid state. It will condense in the pipes.

In order, therefore, to be able to determine whether an oil is appropriate for making gas which shall not condense, its vapour tension at the lowest temperature which it is likely to encounter in the pipes must be known. This can be determined by ascertaining its boiling point, for at the boiling point the tension is, of course, the same for the vapour of all liquids, viz., 30 inches or thereabouts; and, according to a law discovered by Dalton, the tension of the vapours of all liquids is also the same at temperatures equally removed from their respective boiling points. The boiling points are easily determined: indeed, tables are in existence showing the boiling points of a great variety of petroleum oils, and also the density of their vapour at the same temperature; and, as tables of the tension of water vapour at all temperatures from freezing to boiling point are published in most books which treat on the subject of heat, it is easy by the application of Dalton's law to arrive at the vapour tensions and corresponding densities of all oils at all temperatures, and to determine by mathematical calculation what oils will and what oils will not supply sufficient vapour at low temperatures for the purpose of carburetting air, and converting it into what may be practically considered a permanent gas.

Take, by way of example, three of the commonest oils, viz., refined petroleum, which at 243° Fahr., petroleum spirit, boiling at 200° Fahr., both of them in the condition in which they are imported from America; and, thirdly, the petroleum spirit after it has been further refined, which boils at 126° Fahr. It will then be found by calculation that the first-named oil would require to be heated to 118° Fahr. in order to have the requisite density and tension, that is to say, before it can hold the required quantity of carbon; the second oil must be heated to 78° Fahr.; but when using the third, which is that employed by the Author for making gas, its vapour will hold the required quantity of carbon with which to carburet air, and supply a brilliant flame down to 10° Fahr., or 22° below the freezing point of water. It follows, as a matter of course, that at all higher temperatures the air would hold sufficient vapour of this oil without being fully saturated, so that the maximum tension of the vapour would not be attained, and it would remain perfectly elastic, as before explained.

Condensation would commence in the gas, when made from the first-named oil, on the temperature being reduced below 119° Fahr.; and when made from the second-named oil, on the temperature being reduced below 78° Fahr.; so that both these are inappropriate for the purpose of making an illuminating gas of high quality; but it would require that the temperature of the gas should be reduced below 10° Fahr. before any condensation could occur when using the spirit which the Author employs.

Practically, therefore, a perfectly permanent gas is obtained when the spirit is used, which is more even than can be said of coal gas; for coal gas, especially in winter, will always leave some deposit in the pipes in the form of drip liquor, and will consequently lose some of its illuminating power.

It only remains to be mentioned, that by the law regulating the diffusion of gases and vapours, a vapour which has been once diffused in air will never again separate from it so long as its maximum tension is not exceeded.

2. The first cost of the establishment of gasworks on this principle would be much less than the cost of coal gasworks; for they require neither retorts nor chimney stacks, condensers, scrubbers, nor purifiers, and in small places not even a gasholder.

There is no tar to be eliminated, nor ammonia, nor bisulphide of carbon; and the extent of ground required for the site of the works is very limited. An exceedingly small number of men would suffice to superintend and manage the production of the gas, even if manufactured on a much larger scale than the Author contemplates for the present.

With regard to the cost of the gas, the crude petroleum oil in bulk at the wells in Pennsylvania is now sold at from ½*d.* to ¾*d.* per gallon, or from 10*s.* to 15*s.* per ton. The refined petroleum, including the barrels, is put on board at New York at about 6*d.* per gallon; but of this price the barrels, which can be used many times over, represent nearly one-half. In England, the present price of refined petroleum in barrels is about 9½*d.* per gallon; the light spirit costs 1*s.* 1*d.*, and the distillers charge rather more than double that sum for the lightest, which is not yet a commercial article, Should it become so, it is probable that this price could be much reduced.

The gas supplied by the Chartered Gas Company contains, as was previously mentioned, about 100 lbs. weight of carbon in 9,000 cubic feet, which is the average yield of gas from 1 ton of bituminous coal. Now, 100 lbs. of carbon are contained in about 21 gallons of petroleum spirit, the specific gravity of which is 0·655; and this is the quantity of oil required to supply vapour for carburetting 9,000 cubic feet of air. As 1 ton of this spirit contains 367 gallons, it follows that it will make as much gas as 17½ tons o coal.

3. The Author is not disposed to probe the question whether this gas is likely generally to supersede coal gas; and even the matter of convenience, and of the special situations where the system could at once be applied most advantageously, need not be deeply investigated in this Paper. But seeing how easily such a mechanical arrangement as the one described can be carried out on a larger scale, and can everywhere be attended to without skilled workmen being necessary; seeing also that it involves the smallest possible amount of labour in the production of the gas, it cannot but be palpable that the system would be peculiarly useful in many small places where coal gasworks would be inappropriate or too costly.

The Author has applied such machines to large buildings on the continent; and, as an example of what can be successfully done, will mention a large chateau near Brussels which he has recently lighted. There are four floors to the house, besides a coach-house and stables 200 yards off. The central hall is lighted with fifty-four argand lamps on two tiers, one above the other, each lamp being made to burn coal gas at the rate of 9 cubic feet per hour. The rest of the mansion is also brilliantly lighted; and yet the machine only covers a few feet square of space, and stands in the corner of a room in the garret. Motion is given to the fan by a falling weight, which only requires to be wound up every four or five hours, and the gas will continue to burn whilst it is wound up. The cost was £100. The subject excited great interest in Brussels; and, as a proof of its entire success, the Author has been called upon to supply members of the royal family of Belgium and others with similar machines.

This system overcomes the one great difficulty which has hitherto baffled so many inventors from the days of Mr. Mansfield, whose Paper on the subject of catburetted air was read before the Institution in the year 1849, until now viz., the gradual cooling of the liquid is occasioned by the evaporation; for, in the first place, the Author obviates this cooling effect by restoring the heat to the liquid by the immersion of the carburettor in tepid water, or bringing it in contact with steam or hot-water pipes; and, secondly, by using an oil spirit with so low a boiling point as to obtain a sufficient degree

of carburation even at the lowest temperatures.

At an exceedingly small first cost, and by the use of a machine so simple that the dullest of domestic servants would have no difficulty in understanding it, the system enables every man to be master in his own house of his own gas, and this of so pure a quality, that it can with impunity be used in the drawing room or the library, in picture galleries, and even in a lady's boudoir, just as well as any oil-lamp of the most perfect construction.

The Author believes that the system may consequently be regarded, at any rate, as a useful auxilliary of coal gas-works, applicable in England, specially to small towns and villages, to churches, factories, theatres, clubs, hotel, public buildings, and country houses, to railway stations and railway trains, and to the lighting of large steamships.

Owing to the much smaller quantity of hydrogen in it than is contained in coal gas, in the proportion of 13⅓ lbs. to 66⅔ lbs. in 3,000 cubic feet, the cumbustion of 1 cubic foot of the carburetted air only generates one-fourth of the heat which is developed by the combustion of 1 cubic foot of coal gas; and this a further point in its favour for domestic consumption.

But the field for progress in gas manufacture is not confined to England. In many places on the Continent, where coal is expensive, or where there is not a ready sale for coke and other bi-products of the manufacture of coal gas, the system would advantageously compete with coal gas even for town lighting. In the States of South America and Central America coal gas is more expensive, owing to the necessity of importing English coal for its manufacture, and everywhere the price exceeds 20*s.* per 1,000 cubic feet. There is petroleum both in the West Indian Islands and on the western coast of South America, and also in Brazil; and there can be no question that this description of oil gas ought there to be substituted for coal gas.

The same may be said of the large cities in India, and of many cities in the Australasian Colonies, where bituminous shales are met with in great abundance. Petroleum has likewise been found in New Zealand.

Comparatively speaking, petroleum is still quite a new discovery. The first well was sunk in Pennsylvania as recently as the year 1858, and the first well from which the oil flowed naturally, or 'flowing well,' dates from 1861; ever since which the production has each year increased with marvellous rapidity. The district where it is known to exist is 2,000 square miles in extent; but, although several hundred million gallons of oil are now annually raised, it is said that only 1-200th part of that district is as yet worked.

It is known to exist also in Virginia, in Ohio, in Kentucky, in California, and in many parts of the United States, besides being found in Canada and in South America, in China, Japan, Java, on the northern coast of Africa, in Italy, France, Germany, Austria, Wallachia, Turkey, and Russia.

It has recently been discovered in Scotland, on the estates of the Duke of Sutherland, and in North Staffordshire; and there is no reason why, if wells were sunk deep enough, it should not be found in other parts of Great Britain and Ireland.

On the shores of the Caspian Sea it is met with in great abundance, and is used as fuel for the steamers on that sea. It has also been obtained in large quantities from 'flowing wells' in Circassia, within 25 miles of the Black Sea. At Cheeriley, which lies at about the same distance to the west of Kertch, in the Crimea, there are five wells owned by an Englishman, about which the British Consul at that port recently reported officially. At the date of his visit two of the wells were said to be producing at the rate of about one hundred and thirty-five barrels of petroleum daily, and the others a lesser quantity. An extensive zone, well situated for supplying the greater part of Europe, and extending from the Crimea to the Caspian Sea, *i. e.*, for a distance of 800 miles from east to west, appears thus to be indicated.

Bitumen and bituminous shales producing similar oils, are found in every European country, and, indeed, all over the world, in enormous deposits, extending over many thousands of square miles, and varying in depth from 2 or 3 feet to 100 feet.

The West Indian Islands, Trinidad, Cuba, and others, and the coast of Venezuela produce in great quantities a rich bitumen, or asphalte, by the distillation of which from 100 to 140 gallons of oil per ton of mineral are extracted.

In Scotland, large quantities of shale oil are manufactured at a cost of 3¼*d.* per gallon, the mineral being poor in oil, and only producing about 31 gallons per ton.

In Italy, in the valley of Pescara, the bitumen being much richer, the cost is reported by Professor Moffat to be only 1½*d.* per gallon; and in Virginia it is stated that the mining and the distillation of the crude oil is conducted at a cost of only 10*s.* per ton of oil, or ½*d.* per gallon.

There is no need, therefore, to fear that the supply of oil would fail to meet any demand for it which might arise.

4. With reference to the question of safety, it is only necessary to observe that the carburettor containing the petroleum spirit is so made as to be susceptible of being placed at any distance from the building which is to be lighted, and that it might, if necessary, be either buried underground or immersed in water. The petroleum might be stored in the same way. One gallon of spirit will suffice to supply gas to forty burners for six hours, so that the quantity of oil which it would be necessary to use daily in isolated buildings, such as country houses, &c., would be extremely small. The operation of filling the carburettor can easily be so arranged as to make it unnecessary that the oil should ever have to be poured from one vessel into another, so that all possible escape of vapour would be avoided, and no danger of any conceivable kind need be incurred.

The idea that petroleum spirit is explosive is altogether erroneous. In its liquid state in can no more explode than brandy or spirits of wine. The vapour, like gas, will easily take fire, but will not explode in any other sense than this, that if it were allowed to collect in a closed space, such as a room in which the doors and windows were closely shut, then if a lighted candle were brought incautiously into the room, all the vapour would take fire at once, precisely in the same way that gas would do.

The bridge to be built over the Monongahela river, at the "Point," this city, will be constructed on the suspension principle, but instead of wire cables, immense chains will be employed, of which there will be two. These chains will be composed of wrought iron links, each *twenty feet* in length and formed of sixteen flat bars placed side by side, and at a distance from each other of one and two inches. Into these spaces at the ends, fit the bars of the next link, and the entire thirty-two bars are joined by an immense hardened iron pin six inches in diameter and four feet long. The lateral width of the chain is forty inches. At the apex of each iron tower the chain will be attached to an iron "saddle," meeting upon rollers that admit of sufficient play to accommodate the expansion and contraction of the chain from heat and cold. From the top of each tower to the main span, and holding somewhat the same relation to the chain as the string does to the bow, are placed girders, which are intended to prevent sagging of the chains under unusual strain. The plans of the superstructure were prepared by Mr. E. Hemberlee, the American Bridge Company's engineer, which company, as we note elsewhere, has the contract.—*American Manufacturer.*

The contract for the entire work of piers and superstructure of the new 'Point' bridge was awarded last Thursday to the American Bridge Company, of Chicago, at the price named in their proposal, $401,250. The company let the masonry to John Megraw, of Allegheny. The bridge is to be completed for travel by August, 1876. The entire cost, including approaches, etc., will be about $450.000.

Our Exchanges.

The Engineering and Mining Journal, of May 29th, contains a paper on the Musconetcong Tunnel, by Henry S. Drinker, Mining Engineer, and read before the American Institute of Mining Engineers, Feb'y 25th, 1875. The article is a long one, covering nine pages of text and two double page sheets of illustrations. It gives a full account of the progress of the tunnel from its commencement to its completion, and so minutely, that we can especially recommend the paper as being invaluable to every Engineer who wishes to know what the latest improvements in this branch of his profession are. We have made a few extracts from the article for the benefit of our readers, and wish we had space for the entire article; but those engineers really desirous of reading it, will get it by sending ten cents to the publishers, in New York City. We extract the following:

THE MUSCONETCONG TUNNEL.

This tunnel is situated in New Jersey, near the line of the Central R. R. of New Jersey, about twelve miles from Easton, on the Easton and Amboy R. R., the latter being the extension of the Lehigh Valley R. R. to tide-water. Up to the present time the terminus of the Lehigh Valley R. R. has been at Phillipsburg, N. J., opposite Easton, passengers connecting there with New York by the Morris and Essex (D. L. and W.) and N. J. Central lines; freight and coal being forwarded by the Morris and Essex to tide-water at Hoboken, and by the Central R. R. to Elizabethport and Port Johnson; also, by the Belvidere and Delaware connections through Trenton to South Amboy.

By the Easton and Amboy route, the Lehigh Valley R. R. will possess a direct through road for its heavy coal and freight traffic to tide at Perth Amboy, passengers for New York connecting at Metuchin with the Pennsylvania R. R. (Camden and Amboy).

Preliminary lines having been run, the first location was decided on in the autumn of 1871 and winter of 1872, it being such, with regard to alignment and grades, as to ensure the greatest economy in conducting transportation. Construction was commenced in the spring of 1872, and from the first, the tunnel was especially pushed from being the heaviest piece of work on the line. The road, on being ready for construction, was sub-divided into four divisions. Robert H. Sayre, Esq., Chief Engineer of the L. V. R. R., being also Chief Engineer of the Easton and Amboy extension; Calvin E. Brodhead, Esq., Principal Assistant. The tunnel was located in Div. I., John L. Wilson, Esq., Division Engineer, and Henry S. Drinker, Resident Engineer. Charles McFadden, of Philadelphia, took the contract for the tunnel, and for several miles of construction adjoining each extremity.

Musconetcong Mountain is one of a range, around or through which a road from Easton to New York must go. Its summit is about 900 feet above tide-water, and 450 feet above the grade summit, which occurs in the middle of the tunnel, the one adverse grade to transportation occurring in the whole length of the road being between Phillipsburg and this point. The total length of the tunnel is little less than a mile, it being, with the exception of the Hoosac, the longest east of the Mississippi.

DYNAMITE—WHAT IT IS.

It is worth noting what this new explosive, giant-powder or dynamite, is. As to its characteristics—first, it is tremendously powerful, bringing out at a blast masses of rock that black powder could not even shake, and is simply invaluable for rapid driving in hard rock. How it compares economically with pure nitro-glycerine we are not prepared to state. Containing a percentage of the latter, it is of course, not so powerful bulk for bulk, but again it has the great advantage of distributing the force over a greater space, which is the underlying principle of much of the deep hole blasting. Again, so far as an explosive can be termed so, it is entirely safe from accident from the proverbial carelessness of workmen, undoubtedly safer by far than the black powder, while many times stronger. Hardly anything short of a cap exploded in a cartridge will fire it. Alone, it may be hammered, crushed, or burnt with impunity. Thrown into a stove or set on fire, it simply burns fiercely without danger of explosion. For exploding the cartridges very strong caps of fulminate of mercury are used; those adopted at Musconetcong, we believe, were originally imported from Hamburg. These caps are prepared as electric exploders as follows:—First, a small quantity of sensitive powder is dropped on the fulminate, and into this two wires (lying side by side) are inserted, and the caps then filled with melted sulphur. On the sparks passing, the sensitive powder is ignited and explodes the fulminate, and the cap being inserted by the blaster into the cartridge of dynamite, the explosion of the cap fires the latter. If firing by fuse, it is simply necessary for the blaster to squeeze the end of a piece of fuse, properly rasped and sharpened, into the cap, and to place the latter in the cartridge. A good electric battery is that manufactured by the Laflin & Rand Company, under, we believe, Julius Smith's patent, the condenser and generating plate being of vulcanite, and the parts of the battery so arranged as to render it compact and easily handled.

Dynamite is simply nitro-glycerine mixed with a kind of silicious earth known variously as silicious marl, tripoli, and rotten stone. The peculiar variety of this material best suited for this use is homogeneous, has a low specific gravity, and is generally composed of the remains of infusoria. So great is the absorbent capacity of this earth that when in a pulverized condition, it is claimed by Nobel, that it will take up about three times its own weight of liquid nitro-glycerine, and still retain the form of a powder. Any mineral, or indeed vegetable, substance susceptible of pulverization or comminution, and which will retain nitro-glycerine by absorption, may be substituted for infusorial earth in the manufacture of dynamite, but the latter has so far been found to excel all other substances tried in possessing the requirements necessary; being composed of minute tubular shells, it is light and absorbent. A mass of it is very spongy and compressible, its shells absorbing the nitro-glycerine by capillary action, and holding it with almost absolute security against filtration or compression. The secret of the safety of this powder seems to be in its soft, pulpy, and at the same time mealy consistency, which gives it a complete cushion to prevent percussion, as a blow upon it seems like a blow upon a bag of meal; the greater the quantity the more compressibility, and the greater the safety.

THE SURVEY.

The transit used was literally a 'heller,' it, and all the instruments on the work, being made by the well known firm of Messrs. Heller & Brightly, of Philadelphia. The "Gentleman from Drifton" has already had occasion in several interesting papers, to call the attention of the Institute to their mining transit and plummet lamp, and the experience at Musconetcong, most thoroughly endorses the favorable opinion he expresses as to their make. The above transit was unusually large, and of the compound centre class; diameter of graduation of horizontal limb, seven inches; telescope, 17 inches long, acromatic and erecting; magnifying power 28 diameters. A very sensitive bubble is attached to the axis of the telescope, at right angles to the line of sight, and by its careful adjustment and observation, great accuracy may be obtained.

The approach to the tunnel on the west begins on a 5° curve, the P. T. of which is about 800 feet from the entrance, and the tunnel itself located on a tangent throughout its length, the said tangent terminating in a curve, having its P. C. some 1,850 feet beyond the east portal. The grade ran to a summit in the middle of the tunnel, the same being the summit for the road. It was reached by a rise of two-tenths (0.2) to the hundred feet on the west side, or 10.56 feet to the mile, falling on the east at fifteen-hundredths (0.15) to the hundred feet, or 7.92 feet to the mile.

To determine the line after its prelimi-

nary location, an observatory was erected on the summit of the mountain, about 12 feet high, with an eight-foot square base, battering on the four sides about 1½ ins. to the foot. Two solid stone foundations were also built on line, one on a hill at about half a mile from the west entrance, the other on the grading, at the east end, and about half a mile from the eastern portal. As the observatory was located about midway over the tunnel, this gave, approximately, equi-distant sights of about say a mile and a quarter each, at the farthest. This, however, was done after the tunnel had been started from points established on both sides by repeated and carefully checked runnings. The tower being subsequently built, two points were established, one each on the foundations on either side, from the lines by which the work at either end had been so far run, and then assuming these end points as correct, by a series of repeated and careful trials, the center point on the tower, or permanent back-sight for both ends was determined by setting up, approximately, over it, and then reversing and sighting repeatedly, moving the instrument to and fro sideways, within a variable distance of about fifteen-hundreths (0.15) of a foot, in which the sights all came, and finally taking their mean. This was at first done, as soon as the observatory could be located and built, with sufficient accuracy to test the preliminary lines. Subsequently this center point was tested, and re-tested, and determined with extreme accuracy, by the mean of very many trials made both by sighting by day and by night, and in winter and summer. Different objects were used for sighting on in day-work, Both the ordinary red and white round pole, also a flat 2x1 inch black pole, with a white centre streak. This latter, from its shape, was found difficult to keep plumb, either when held or fastened. Also a pole of one-half inch round iron, painted white, was tried, and found to answer well, better than either of the others. But far better and more accurate than any day-light back-sight, whether permanent or moveable, was found the simple expedient of using plummet lamps on clear calm nights. They worked admirably outside, a flame ¾-inch high, by ⅓-inch in diameter, being distinctly seen in the long sights, and with a fine hair, the sights were found, finally, to repeatedly test within practically such exact limits (two or three hundredths), that the point being once fixed, it was not subsequently found advisable to move it. Now, these three reference points being located, at the west end a centre was set at the mouth of the slope, and from it another at the bottom. This gave a back-sight of 276 feet to run from into the heading. At each shaft a centre was first set, with great care, about twenty-five feet off, and from this the line prolonged to two staples driven into the timbers on each side. On the mean of many sights being determined, the points on both staples were notched, the notches tested, and fine plummet lines dropped from them, the weights being steadied, at the bottom in water. Then the line was continued from these, as in ordinary mine surveying, in running from a shaft, the instrument being first approximately set up in line, and then moved sideways, until the hair exactly bisected the mean of the slight oscillations observable in the lines. Though the distance to be run from the shafts was not great, this care was necesssry from the shortness of the back-sight, the distance between staples being only some 7½ feet, and from the fact that the headings were through earth, it being very necessary in enlarging through earth to be able to have the crown bars closely located at equi-distant spaces from centre. On the headings between the shafts and slope meeting, the various runnings all tested closely, but it was the long line between the main east and west headings, that required of course the most care, and caused the most anxiety. This line, at the east end, was simply continued, on the grading, up into the heading, at first with one, and, subsequently, as the headings advanced, with two intermediate centres. At the west end, the line was at first run into the main heading down the slope, but as the enlargement in soft ground proceeded between the slope and west end, in time a clear sight was obtained from the mouth of the tunnel to the slope, and thence into the heading, making two intermediate centres, as at the east end. It was always necessary to have a station where the slope came down, since the latter was driven, after meeting rock, sixteen feet wide—thirteen on the left and three on the right of centre line, leaving at its foot about ten feet of space for passage on the right, as the line ran, and, of course, cutting off centre line. The three feet on the right, however, were dressed off, subsequently, at the level of the heading, so as to give a clear back-sight to the mouth.

The east and west lines were repeatedly run and tested as the headings advanced, and, besides the work continually spent on them by the Division and Resident Engineers, they were frequently checked by the Principal Assistant Engineer. They finally tested within four-hundredths (0.04) of a foot, or less than one-half an inch. The levels were carried over the mountain by a series of test benches run until succeeding benches tested within five thousandths (0.005) of a foot. On meeting, the face benches on either side were found to test within fifteen thousandths (0.015) of a foot, or less than one-fifth of an inch. Owing to the system of centre cuts, used in blowing the rock, in which ten feet at a time were brought out, it was especially necessary that the chaining should be accurate, so that the distance apart of headings might be safely determined. To measure over the mountain, two stout frames were made, steadied by weights on the legs. They each simply consisted of a vertical shaft with three legs, one moveable. From a board nailed on top of the shaft a fine plummet was hung. The two were put in line, the plummets centered by the transit, and a point at the top of one line levelled with a point near the bottom of the other, and the measurement thereon taken between the two with steel tape. The hind frame was then moved on, and the chaining so carried up or down hill in successive steps. This method was found to be satisfactory; for, on the headings coming together, the distance apart, predicted and marked, was found to agree with the measured distance within fifty-two hundredths (0.52) of a foot, or about six inches out in a total chaining of about eight thousand feet, four thousand through headings, and four thousand over the mountain, the test measurements being brought down the slope on angle instead of in at the west entrance.

Laws Relative to Farm Property.

IRRIGATION.

It has sometimes been made a question whether a riparian proprietor can direct water from a running stream for purposes of irrigation.

The language of the Court as best defining the principles governing this subject is as follows, to wit: "That an individual owning a spring on his land, from which water flows in a current through his neighbor's land would have the right to use the whole of it, if necessary, to satisfy his natural wants. He may consume all the water for his domestic purposes, including water for his stock. If he desires to use it for irrigation, and there is a lower proprietor to whom its use is essential to supply his natural wants, or for his stock, he must use the water so as to leave enough for such lower proprietor. Where the stream is small and does not supply water more than sufficient to answer the natural wants of the different proprietors living on it, none of the proprietors can use the water for irrigation or manufactures. — *Massachusetts Agricultural Report, 1872-3.*

Papers have recently been filed in Harrisburg for the incorporation of the Pittsburgh and Lake Erie railroad. The certificate sets forth the route of the new line as follows: Beginning at the Connellsville depot, Pittsburg, thence down the Ohio river to the mouth of Big Beaver at Rochester; thence up the Beaver and and Mahoning to the state line near Youngstown, where it forms connection with Lake Erie. The directors of this road are Wm. McCreery, W. M. Short, John Bissell, P. W. Keller, A. J. McKinley, Joshua Rhodes, James Westerman, Geo. C. Reis, and John F. Dravo.